Fukushima Daiichi Nuclear Power Station
Completion of the Investigation into the Cause of the Unit 2 SFP Primary Cooling System Pipe Rupture

- We have been engaged in a scheduled shutdown of the Unit 2 spent fuel pool (SFP) primary cooling system ever since a drop in the water level of the skimmer surge tank (tank used to confirm that the spent fuel pool is filled with water) was noticed on August 9.
- Since a subsequent investigation found that a leak caused by a rupture in a pipe on the third floor of the reactor building was the cause of the drop in water level, we began to make repairs and also configure a substitute cooling line to prepare for such nonconformities if they were to occur again.
- The rupture formed at a weld connecting two different materials, carbon steel and stainless steel, and it is likely that this weld of dissimilar metals was the cause of the rupture. Therefore, an investigation was performed to search for similar locations in the primary cooling system piping, and we discovered corrosion in the pipes on the fourth floor of the reactor building as well.
- Now that the ruptures and corrosion have been repaired and a substitute cooling line has been configured, on November 19, we commenced the trial operation of the primary cooling system and are making preparations to recommence full-scale cooling.

＜Announced by November 18＞

- Investigation of the inside of pipes around the rupture and other joints where different materials have been welded together found that the cause of the pipe rupture was most likely twofold. Firstly, seawater, etc. injected during/after the disaster caused corrosion that covered the entire inside of the pipes. Secondly, when dissimilar metals are welded together and subjected to a highly conductive liquid, contact corrosion (galvanic corrosion) will ensue.
- During the course of the investigation, pipe corrosion was newly found in two other locations that are currently being repaired. After these pipe repairs have been completed and pipe integrity has been confirmed through trial operation, we shall recommence operation of the primary cooling system.
- Furthermore, since making the cooler system safer and more reliable than ever, we continue to deliberate the construction of a new cooling method that is not dependent upon the primary cooling system.
- We are also conducting an investigation of dissimilar metal welds at Unit 1 SFP, which still contains fuel just like Unit 2. We shall continue to prioritize safety during these investigations and implement countermeasures as needed.

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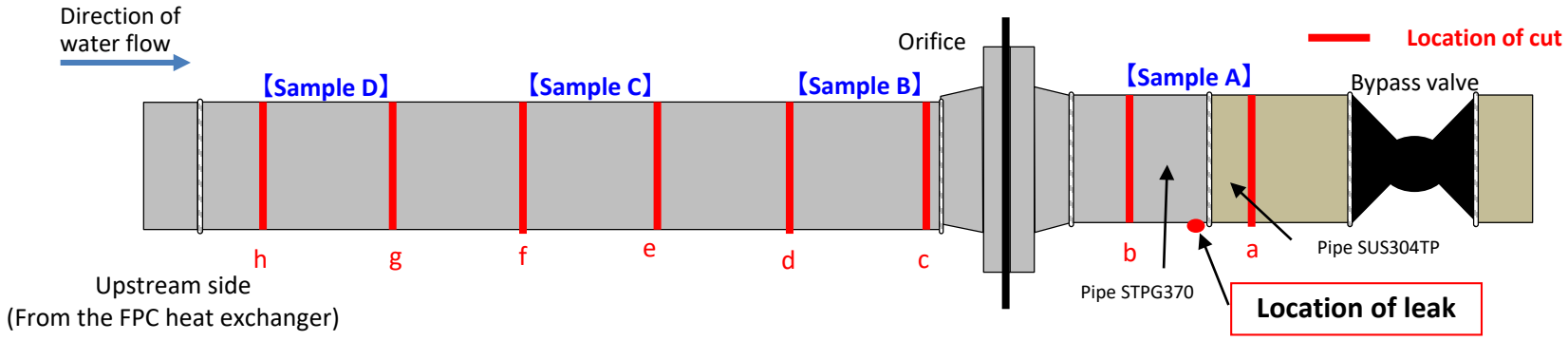
Investigation ① (Examining the inside of pipes around the leak)

As shown below, samples A~D were cut out of the pipes in the vicinity of the leak to examine the status and composition of deposits inside them, measure the thickness of the pipes, and check for corrosion inside.



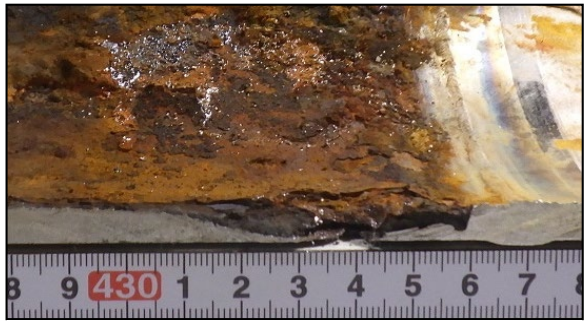
【 Deposits 】

- Adhesions cover the inside of Samples A~D
- Most are iron oxide

Deposits inside the pipe (Sample B)

【 Pipe thickness 】

- Remarkable thinning of the carbon steel pipe was found near the leak location
- There was less thinning the further you move away from the weld of dissimilar metals



Remarkable thinning around the area of the leak (Sample A)

【 Inside surface of pipes 】

- The entire inside surface of Samples A~D were corroded

Corrosion inside the pipe (Sample D)

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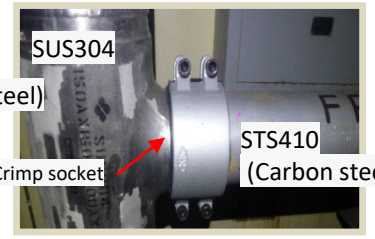
Investigation ② (Examining dissimilar metal joint welds)

- Including the leak location (①), there were 12 dissimilar metal pipe welds.
- ② ③ ⑫ have corrosion that was found on the outer surface of the pipes at three locations (shown by the red circles).
- ① ② ⑫ have been repaired. ③ will be repaired by the time the primary cooling system is put back into operation.
- ④ ⑤ are embedded in frame concrete so the outer surface of the pipes cannot be examined (shown by the green circles).
  ※ Water passage tests and trial operation have confirmed that there are no abnormalities such as leaks, etc.
- ⑥～⑪ were subjected to visual pipe inspections and pipe thickness measurements, and we've confirmed that there are no abnormalities (shown by the blue circles).

＜ Example of outer surface corrosion/repairs at location ②＞

＜ Prior to repairs ＞

＜ After repairs ＞



Unit 2 SFP system diagram

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Assumed causes

■ **Key Assumptions**

- Since seawater, etc. injected during/after the disaster, the system water in the Unit 2 SFP contained impurities and had increased conductivity.
- The leak locations is located near the area of a weld connecting two different materials, carbon steel and stainless steel.
- A recirculating cooling water was retained because the pipes in the leak locations has not been used after the disaster.

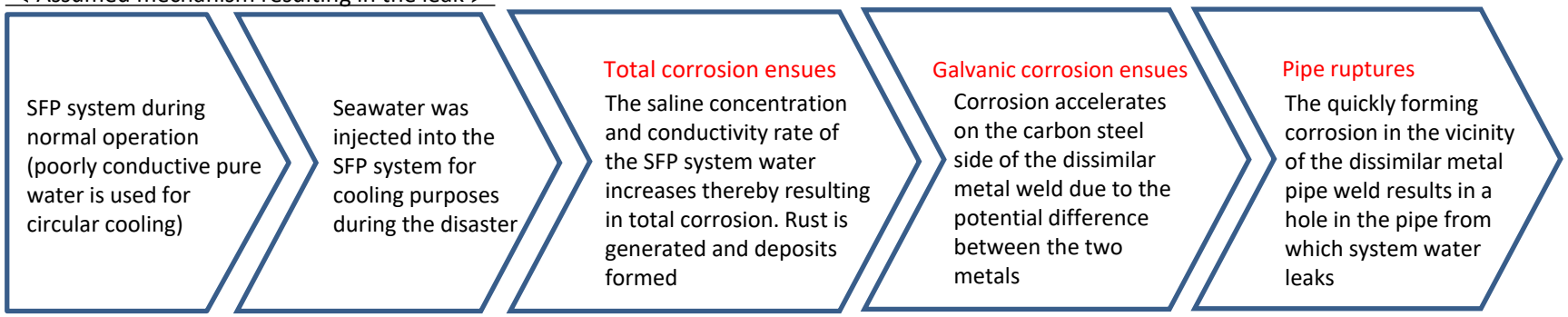
■ **Investigation discoveries**

- While substantial thinning of the metal in the vicinity of the leak (on the carbon steel side of the dissimilar metal weld) was confirmed, the thinning dissipated the further away from the weld you got leaving sufficient pipe thickness.
- Deposits comprised of mostly iron oxide (metal rust) were found all over the inside of the pipes around the location of the leak
- Corrosion on the outer surface of the pipes was found at three other dissimilar metal pipe welds that are like the location of the leak.

■ **Assumed causes**

- In addition to corrosion of the entirety of the inside of the pipes caused by an increase in the saline concentration of the system water, corrosion caused by the welding of dissimilar metals (galvanic corrosion) was found near the dissimilar metal weld, and it is this corrosion that resulted in the pipe rupture and the leak of SFP system water.

＜Assumed mechanism resulting in the leak＞



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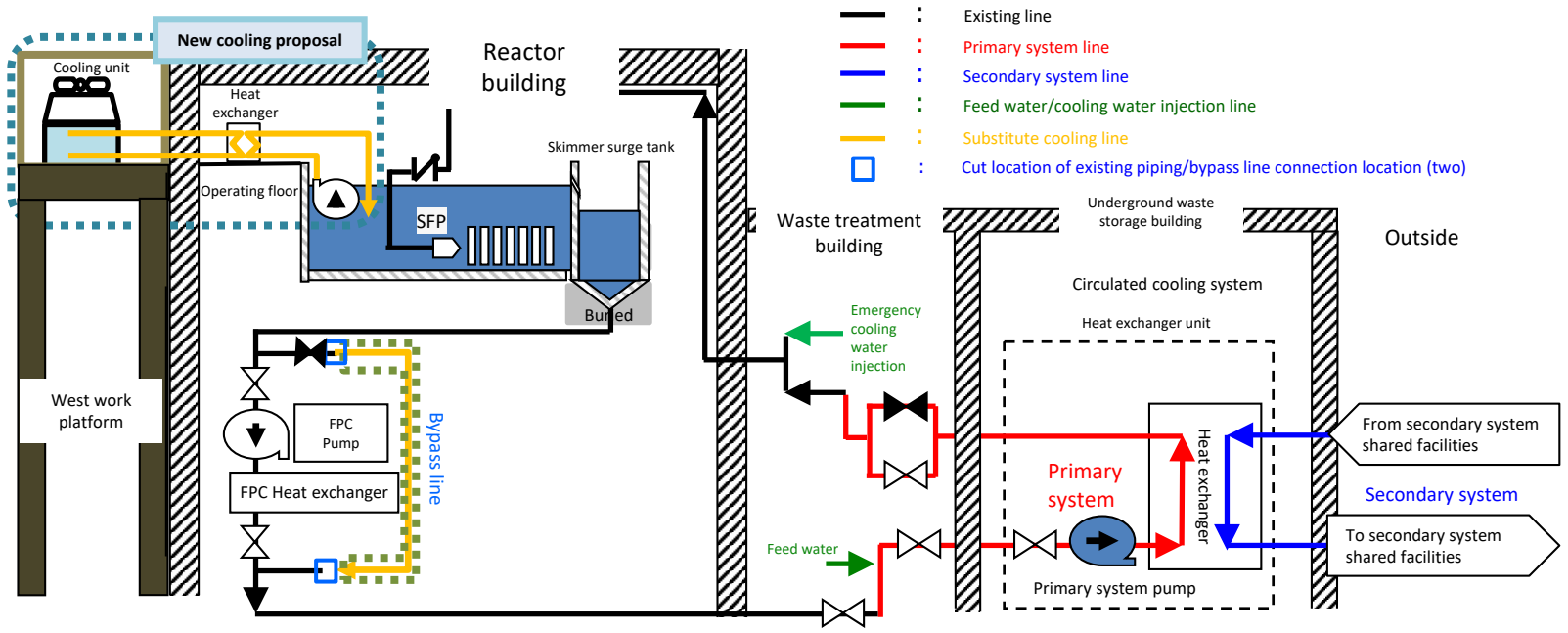
Countermeasures

【 **Implemented countermeasures** 】

- Leak repairs
- Repairs to three pipe locations at which outer surface corrosion was discovered (Two locations have been repaired. The remaining one is scheduled to be repaired before the resumption of operation of the circulation cooling system)
- Configuration of a bypass line to be prepared for nonconformities involving the FPC pump or FPC heat exchanger

【 **Ongoing countermeasures** 】

- It will be confirmed that water is not leaking from the dissimilar metal welds (two) that could not be visually inspected during the field check by monitoring skimmer surge tank water levels and the level of stagnant water in the building since, if there was a leak, that water would flow into the building via floor funnels.
- Since making the cooler system safer and more reliable than ever, we will deliberate the configuration of a new cooling system (refer to the diagram below) that takes water from the SFP.
- Dissimilar metal welds in the cooling system pipes of the Unit 1 SFP, which still contains fuel, will be investigated and countermeasures implemented if necessary.



Unit 2 SFP system diagram

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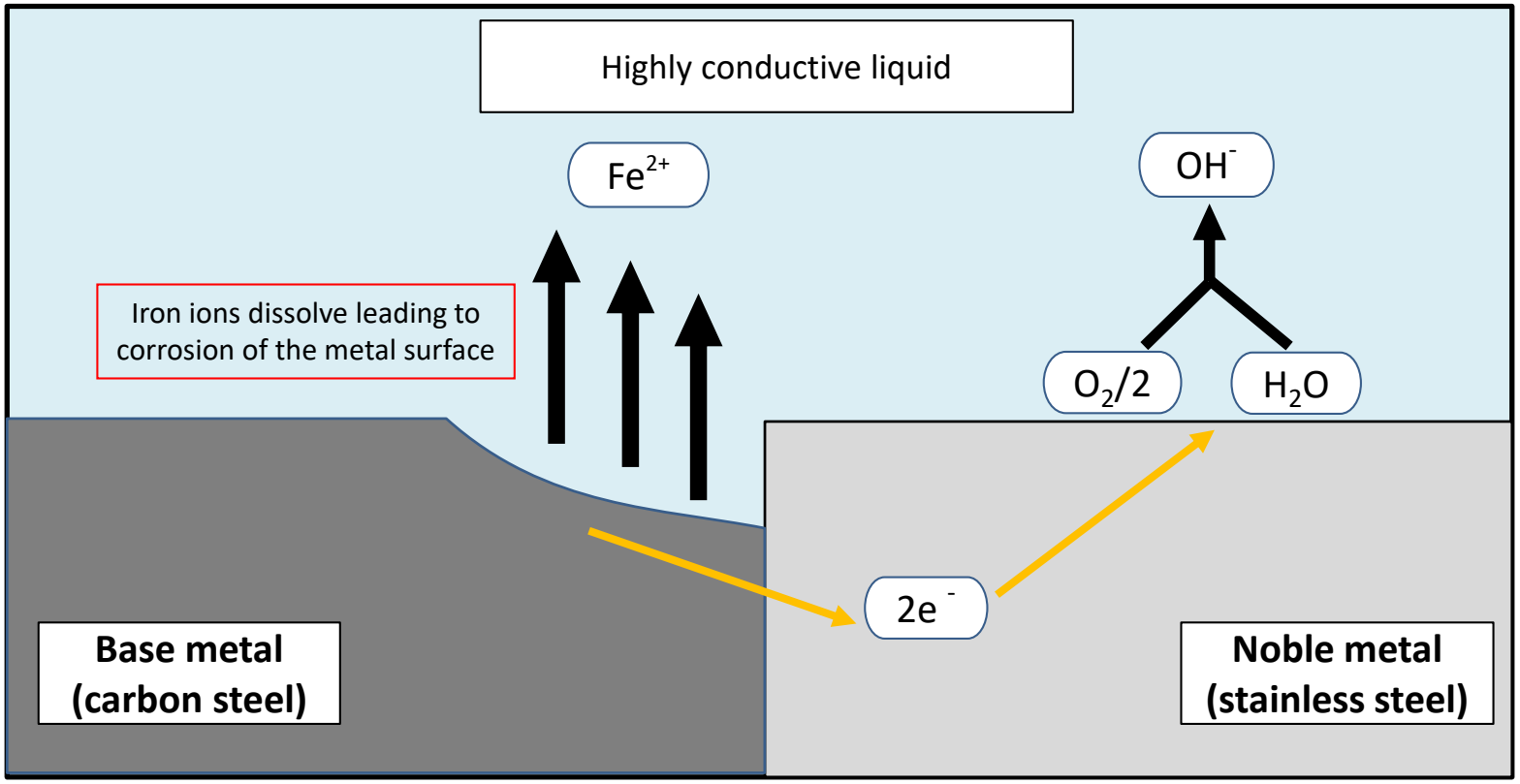
[Reference] Dissimilar metal contact corrosion (galvanic corrosion)

Phenomenon that occurs when dissimilar metals are in contact in a highly conductive environment, such as in saltwater. In conjunction with the migration of electrons, metal ions dissolve into the base metal side (side that loses electrons) causing corrosion.



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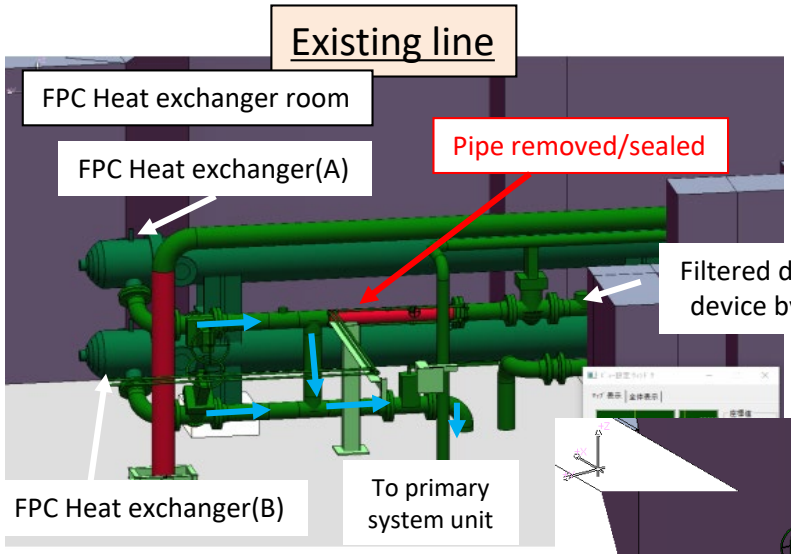
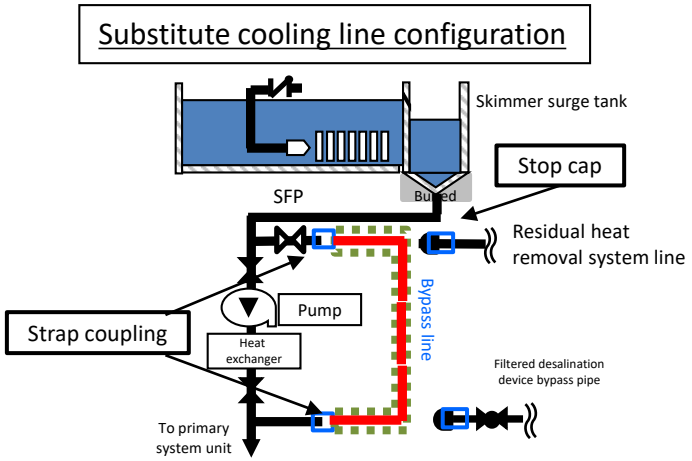
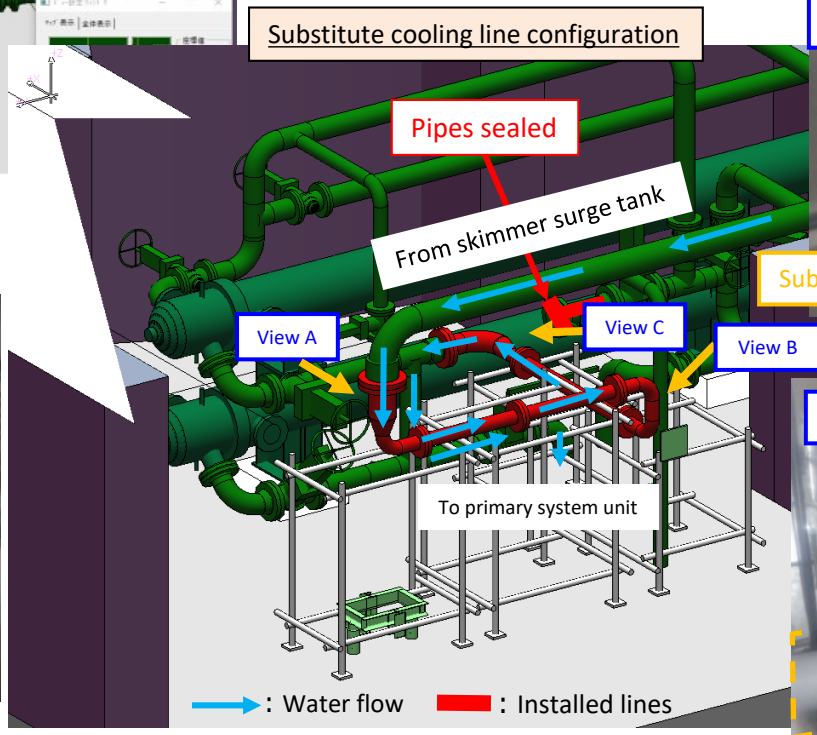
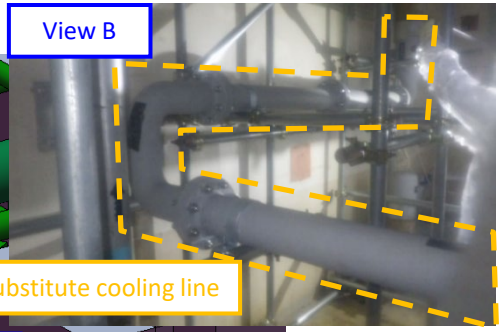
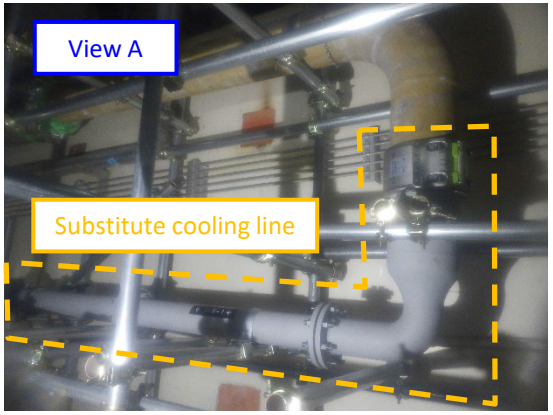
[Reference] Stopping the leak and configuring a substitute cooling line

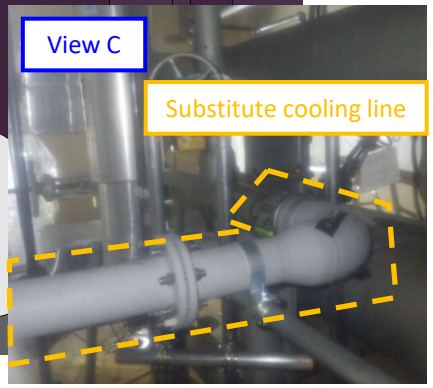












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